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TITLE: Method and apparatus for automatically analyzing trace substance

Samples of clean gas of Room in which semiconductors are fabricated

Abstract Text - ABTX (1):

An apparatus for automatically analyzing a trace substance capable of automatic analysis of a trace substance in a short time with high accuracy is provided. This apparatus comprises (a) samplers for making samples each containing a desired substance at different sampling points, (b) concentrators for concentrating the substance contained in the samples to thereby produce concentrated samples, (c) a quantitative analyzer for analyzing quantitatively the substance contained in the concentrated samples, and (d) a controller for controlling the samplers, the concentrators and the analyzer to cause automatically operations of the samplers, the concentrators, and the analyzer repeatedly at specific intervals of time. Each of the concentrators receives alternatively the samples from at least two of the samplers. The analyzer receives alternatively the concentrated samples from the concentrators. Preferably, the desired substance is gaseous and each of the concentrators has a diffusion scrubber and a concentration column. A cleaner for cleaning the samplers by supplying a purging gas into the samplers may be additionally provided.

Brief Summary Text - BSTX (3):

The present invention relates to a method and an apparatus for automatically analyzing a trace substance, and more Particularly, to a method and an apparatus for automatically analyzing a desired gaseous substance or substances existing in an atmosphere, which are preferably applied to monitoring gaseous contaminants existing in a clean room used in the field of semiconductor device fabrication.

Brief Summary Text - BSTX (5):

A trace of gaseous contaminant remaining in a clean room atmosphere tends to increasingly cause failures or defects in next-generation semiconductor devices during their fabrication process steps. To stabilize the prosecution of the mass-production processes of the next-generation semiconductor devices, usually, suitable dust/chemical filters are used for removing dusts and chemicals existing in the air in the clean room. However, there is a possibility that contamination accidents occur due to supplied source

materials for fabrication processes and that the dust/chemical filters may be damaged or broken due to contaminants. Thus, it is required to automatically and continuously measure and monitor contaminants existing in the air in a clean room.

Brief Summary Text - BSTX (7):

On the other hand, there is a known prior-art multi-point analyzing method for automatically analyzing ammonia existing in a clean room atmosphere using a diffusion scrubber. FIGS. 1 and 2 show prior-art multi-point ammonia analytical apparatuses that perform this analyzing method, which are disclosed in the Japanese Non-Examined Patent Publication No. 8-54380 published in June 1994 and its corresponding U.S. Pat. No. 5,714,676 issued on Feb. 3, 1998.

Brief Summary Text - BSTX (8):

In FIG. 1, the prior-art multi-point ammonia analytical apparatus is comprised of a sampler 1100, a concentrator 1200, and an analyzer 1300. The sampler 1100 has a switch valve 601 with ten inlets connected respectively with ten sampling points P1 to P10 located in the clean room, and a diffusion scrubber 602 connected to an outlet of the valve 601. The concentrator 1200 includes a concentration column 604 of an ion chromatograph 603. The analyzer 1300 includes a separation column 605, a suppressor 606, and an electrical conductivity meter 607 of the ion chromatograph 603. A controller 608 controls the whole operation of the sampler 1100, the concentrator 1200, and the analyzer 1300.

Brief Summary Text - BSTX (11):

In the prior-art analytical apparatus of FIG. 1, the switch valve 601 of the sampler 1100 assigns alternately one of the sampling points P1 to P10 to the diffusion scrubber 602. Thus, there is a problem that the total measuring time T.sub.total for all the sampling points P1 to P10 is very long.

Brief Summary Text - BSTX (14):

The sampler 2100 has a switch valve 701a having five inlets connected respectively with five sampling points P1 to P5, a diffusion scrubber 702a connected to an outlet of the valve 701a, a switch valve 701b having five inlets connected respectively with five sampling points P6 to P10, and a diffusion scrubber 702b connected to an outlet of the valve 701b.

Brief Summary Text - BSTX (38):

In a preferred embodiment of the apparatus according to the first

aspect, the desired substance is gaseous and each of the concentrators has a diffusion scrubber and a concentration column.

Brief Summary Text - BSTX (39):

In another preferred embodiment of the apparatus according to the first aspect, the desired substance is gaseous and each of the concentrators has four diffusion scrubbers and two concentration columns.

Brief Summary Text - BSTX (45):

Each of the diffusion scrubbers may have the cleaner.

Brief Summary Text - BSTX (46):

According to a second aspect of the present invention, another apparatus for automatically analyzing a trace substance is provided, which is comprised of (a) a sampler for making a sample containing a desired substance at a sampling point, the sampler including a diffusion scrubber, (b) a concentrator for concentrating the substance contained in the sample to thereby produce a concentrated sample, the concentrator including a concentration column, (c) a quantitative analyzer for analyzing quantitatively the substance contained in the concentrated sample, (d) a cleaner for cleaning the sampler by using a purging gas, and (e) a controller for controlling the sampler, the concentrator, the analyzer, and the cleaner to cause automatically operations of the sampler, the concentrator, the analyzer, and the cleaner repeatedly at specific intervals of time.

Brief Summary Text - BSTX (48):

In a preferred embodiment of the apparatus according to the second aspect, the cleaner is comprised of a tank for storing a purging gas, and a valve for connecting the tank with the diffusion scrubber of the sampler.

Brief Summary Text - BSTX (49):

In another preferred embodiment of the apparatus according to the second aspect, an additional sampler for making an additional sample containing the desired substance at a sampling point, the additional sampler including a diffusion scrubber. The two diffusion scrubbers of the samplers are alternately connected to the concentrator. The cleaners are designed for cleaning the two samplers.

Detailed Description Text - DETX (6):

Each of the samplers 100a, 100b, 100c, and 100d, which is

communicated with ten sampling points P1, P2, P3, P4, P5, P6, P7, P8, P9, and P10 set at different locations in a clean room for semiconductor device fabrication, samples the air at any one of the ten points P1 to P10. The sampled air contains trace substances such as ammonia existing in the clean room. The trace substances in the sampled air are then absorbed into an absorbing liquid in the corresponding sampler, making a sample of the trace substances. The samples of the trace substances in the absorbing liquid, which are respectively emitted by the samplers 100a, 100b, 100c, and 100d, are termed AL1, AL2, AL3, and AL4, respectively.

Detailed Description Text - DETX (15):

As shown in FIG. 7, the sampler 100a includes a 10-way switch valve 21 and a diffusion scrubber 17. The valve 21 has ten inlets connected respectively to ten sampling tubes T1, T2, . . . , T10 and one outlet connected to the scrubber 17. The ends of the tubes T1 to T10 are located at the sampling points P1 to P10, respectively. Because of the switching operation of the valve 21, the air existing at one of the sampling points P1 to P10 is alternately taken into the diffusion scrubber 17 through a corresponding one of the tubes T1 to T10 and the valve 21, thereby outputting a sample A1 of the air to the scrubber 17. The sample A1 of the air contains ammonia and other trace substances.

Detailed Description Text - DETX (16):

Similarly, the sampler 100b includes a 10-way switch valve 22 and a diffusion scrubber 18. The valve 22 has ten inlets connected respectively to the same sampling tubes T1 to T10 and one outlet connected to the scrubber 18. Because of the switching operation of the valve 22, the air existing at one of the sampling points P1 to P10 is alternately taken into the diffusion scrubber 18 through a corresponding one of the tubes T1 to T10 and the valve 22, thereby outputting a sample A2 of the air to the scrubber 18. The sample A2 of the air contains ammonia and other trace substances.

Detailed Description Text - DETX (17):

The sampler 100c includes a 10-way switch valve 23 and a diffusion scrubber 19. The valve 23 has ten inlets connected respectively to the same sampling tubes T1 to T10 and one outlet connected to the scrubber 19. Because of the switching operation of the valve 23, the air existing at one of the sampling points P1 to P10 is alternately taken into the diffusion scrubber 19 through a corresponding one of the tubes T1 to T10 and the valve 23, thereby outputting a sample A3 of the air to the scrubber 19. The sample A3 of the air contains ammonia and other trace substances.

Detailed Description Text - DETX (18):

The sampler 100d includes a 10-way switch valve 24 and a diffusion scrubber 20. The valve 24 has ten inlets connected respectively to the same sampling tubes T1 to T10 and one outlet connected to the scrubber 20. Because of the switching operation of the valve 24, the air existing at one of the sampling points P1 to P10 is alternately taken into the diffusion scrubber 20 through a corresponding one of the tubes T1 to T10 and the valve 24, thereby outputting a sample A4 of the air to the scrubber 20. The sample A4 of the air contains ammonia and other trace substances.

Detailed Description Text - DETX (20):

Each of the diffusion scrubbers 17, 18, 19, 20 has the same configuration as that disclosed in the Japanese Non-Examined Patent Publication No. 8-54380. Specifically, each of the scrubbers 17, 18, 19, and 20 is comprised of an inner tube (not shown) and an outer tube (not shown) fixed coaxially to the inner tube. The inner tube includes a micro-porous membrane (not shown) allowing gaseous substances to penetrate through the membrane and preventing a liquid from penetrating through the same. An absorbing liquid or absorbent is moved through the space between the inner and outer tubes while the sample A1, A2, A3, or A4 of the air is moved through the inside of the inner tube. The gaseous substances (e.g., ammonia) contained in the sample A1, A2, A3, or A4 are absorbed into the absorbing liquid through the micro-porous membrane of the inner tube, thereby producing the sample AL1, AL2, AL3, or AL4 of the gaseous substances contained in the absorbing liquid.

Detailed Description Text - DETX (21):

The concentrator 200a is connected to the two diffusion scrubbers 17 and 18. The concentrator 200a is alternately supplied with one of the samples AL1 and AL2 of the substances from the scrubbers 17 and 18, thereby concentrating the trace substances contained in the samples AL1 and AL2. Thus, the concentrated sample CL1 of the trace substances is produced. The concentrated substances held in the concentrator 200a are dissolved in an eluting liquid and then, they are taken out of the concentrator 200a.

Detailed Description Text - DETX (22):

Similarly, the concentrator 200b is connected to the two diffusion scrubbers 19 and 20. The concentrator 200b is alternately supplied with one of the samples AL3 and AL4 of the trace substances from the scrubbers 19 and 20, thereby concentrating the trace substances contained in the samples AL3 and AL4. Thus, the concentrated sample CL2 of the trace substances is produced. The concentrated substances

held in the concentrator 200b are dissolved in an eluting liquid and then, they are taken out of the concentrator 200b.

Detailed Description Text - DETX (26):

In the "pre-treatment operation", the absorbing liquid is circulated through the diffusion scrubbers 17, 18, 19, and 20 to suppress the effect of the residue occurred in a prior measurement step.

Detailed Description Text - DETX (28):

In the "sampling operation", the absorbing liquid is circulated between the diffusion scrubbers 17, 18, 19, and 20 and the concentration columns 26 and 27 to thereby cause the trace substances contained in the samples Al to A4 of the air to be absorbed in the absorbing liquid, resulting in the samples AL1 to AL4 of the trace substances. Then, the trace substances contained in the samples AL1 to AL4 are concentrated by the concentrators 200a and 200b, producing the samples CL1 or CL2 of the trace substances.

Detailed Description Text - DETX (34):

The diffusion scrubber 17 has an air path 17a through which the sampled air flows and a liquid path 17b through which the absorbing liquid flows. The air path 17a connects the outlet of the valve 21 to one end of a trap 33 through the diffusion scrubber 17. The air path 17a is further connected to an exhaust port of the apparatus through a mass flow controller (MFC) 29, a suction pump 9, and a trap 37. Two ends of the liquid path 17b are connected to two ports of an 8-port valve 1, respectively.

Detailed Description Text - DETX (35):

Similarly, the diffusion scrubber 18 has an air path 18a through which the sampled air flows and a liquid path 18b through which the absorbing liquid flows. The air path 18a connects the outlet of the valve 22 to one end of a trap 34 through the diffusion scrubber 18. The air path 18a is further connected to an exhaust port of the apparatus through a MFC 30, a suction pump 10, and a trap 38. Two ends of the liquid path 18b are connected to two other ports of the 8-port valve 1, respectively.

Detailed Description Text - DETX (36):

The diffusion scrubber 19 has an air path 19a through which the sampled air flows and a liquid path 19b through which the absorbing liquid flows. The air path 19a connects the outlet of the valve 23 to one end of a trap 35 through the diffusion scrubber 19. The air path

19a is further connected to an exhaust port of the apparatus through a MFC 31, a suction pump 11, and a trap 39. Two ends of the liquid path 19b are connected to two ports of an 8-port valve 5, respectively.

Detailed Description Text - DETX (37):

The diffusion scrubber 20 has an air path 20a through which the sampled air flows and a liquid path 20b through which the absorbing liquid flows. The air path 20a connects the outlet of the valve 24 to one end of a trap 36 through the diffusion scrubber 20. The air path 20a is further connected to an exhaust port of the apparatus through a MFC 32, a suction pump 12, and a trap 40. Two ends of the liquid path 20b are connected to two other ports of the 8-port valve 5, respectively.

Detailed Description Text - DETX (38):

The diffusion scrubbers 17, 18, 19, and 20 have an equal length of, for example, 80 cm. To ensure a desired sampling or collecting rate of the air in the clean room, the length is preferably 80 cm or longer. Although this length may be shorter than 80 cm, there is a possibility that the measured values of the substances contain significant errors.

Detailed Description Text - DETX (39):

The traps 33, 34, 35, and 36 serve to trap the leakage of the absorbing liquid from the scrubbers 17, 18, 19, and 20 and the moisture from waterdrops induced by pressure difference, respectively. The traps 33, 34, 35, and 36 are located at levels lower than those of the corresponding scrubbers 17, 18, 19, and 20. Inlets of the traps 33, 34, 35, and 36 are connected to the ports of the corresponding scrubbers 17, 18, 19, and 20, respectively. Outlets of the traps 33, 34, 35, and 36 are connected to the ports of the corresponding MFCs 29, 30, 31, and 32, respectively.

Detailed Description Text - DETX (41):

The pumps 9, 10, 11, and 12 are used to suck the air at the sampling points P1 to P10 in the clean room to the diffusion scrubbers 17, 18, 19, and 20 through the air paths 17a, 18a, 19a, and 20a, respectively. The exhaust ports of the pumps 9, 10, 11, and 12 are connected to the traps 37, 38, 39, and 40, respectively. The traps 37, 38, 39, and 40 serve to trap the waterdrops induced by pressure difference or the like. The traps 37, 38, 39, and 40 are located at levels lower than those of the corresponding pumps 9, 10, 11, and 12.

Detailed Description Text - DETX (42):

A pre-treatment pump 13 serves to suck the absorbing liquid stored in a container (not shown) through a degasser 41 and sends it to the valve 1. The valve 1 serves to supply alternately the absorbing liquid thus sucked to one of the diffusion scrubbers 17 and 18. Also, the valve 1 serves to discharge the absorbing liquid having passed through the diffusion scrubber 17 or 18 to the outside.

Detailed Description Text - DETX (43):

A pre-treatment pump 16 serves to suck the absorbing liquid stored in a container (not shown) through a degasser 44 and sends it to the valve 5. The valve 5 serves to supply alternately the absorbing liquid thus sucked to one of the diffusion scrubbers 19 and 20. Also, the valve 5 serves to discharge the absorbing liquid having passed through the diffusion scrubber 19 or 20 to the outside.

Detailed Description Text - DETX (44):

As described above, each of the diffusion scrubbers 17, 18, 19, and 20 causes the trace substances contained in the air to be absorbed into the absorbing liquid flowing through the inside of the corresponding scrubber 17, 18, 19, or 20. This configuration is already known by the Japanese Non-Examined Patent Publication No. 8-54380 and soon.

Detailed Description Text - DETX (45):

An absorbing-liquid-circulating pump 14 serves to suck the absorbing liquid stored in a container (not shown) through a degasser 42 and a valve 3. Also, the pump 14 serves to circulate the absorbing liquid thus sucked through a circulating path by way of the pump 14, a valve 4, the concentration column 26, the vale 2, the valve 1, the diffusion scrubber 17 or 18, the valve 1, the valve 2, a trap 50, and the valve 3. The degasser 42 serves to remove foams existing in the absorbing liquid,

Detailed Description Text - DETX (46):

Similarly, an absorbing-liquid-circulating pump 15 serves to suck the absorbing liquid stored in a container (not shown) through a degasser 43 and a valve 7. Also, the pump 15 serves to circulate the absorbing liquid thus sucked through a circulating path by way of the pump 15, a valve 8, the concentration column 27, the vale 6, the valve 5, the diffusion scrubber 19 or 20, the valve 5, the valve 6, a trap 51, and the valve 7. The degasser 43 serves to remove foams existing in the absorbing liquid.

Detailed Description Text - DETX (62):

In the step S1, the "pre-treatment operation" is carried out, in which the absorbing liquid (i.e., ultrapure water) is supplied to the diffusion scrubbers 17, 18, 19, and 20 to clean their inside and the relating flow paths. Thus, the remaining trace substances in a prior measurement step are removed. The absorbing liquid thus supplied is then discharge to the outside

Detailed Description Text - DETX (64):

In the step S3, the "sampling operation" is carried out, in which the sampled air and the absorbing liquid (i.e. , ultrapure water) are supplied to the diffusion scrubbers 17, 18, 19, and 20. The trace substances contained in the sampled air are absorbed into the absorbing liquid in the scrubbers 17, 18, 19, and 20. The absorbing liquid having the absorbed trace substances is supplied to the concentration column 26 or 27, thereby concentrating and holding the substances in the column 26 or 27. The absorbing liquid from which the substances have been extracted is returned to the scrubbers 17, 18, 19, and 20.

Detailed Description Text - DETX (67):

As seen from Table 1, the valve 21 connects the sampling point P1 with the diffusion scrubber 17 at the first measurement. At this time, the valves 22, 23, and 24 connect the sampling points P2, P3, and P4 with the diffusion scrubbers 18, 19, and 20, respectively .

Detailed Description Text - DETX (68):

At the second measurement, the valves 21, 22, 23, and 24 connect the sampling points P5, P6, P7, and P8 with the diffusion scrubbers 17, 18, 19, and 20, respectively. The assignment of the sampling points P1 to P10 is carried out in the predetermined sequence or manner shown in Table 1 at the third measurement or later.

Detailed Description Text - DETX (72):

Here, as shown in Table 1, it is supposed that the sample air sampled at the point P4 contains a high-concentration desired substance (i.e., ammonia), in other words, the measured concentration of the ammonia exceeds the specific warning limit necessitating a specific caution or warning, in the sixth measurement step. This is shown by a character X at the bottom of Table 1. In this case, under the control of the controller 400, the diffusion scrubber 20 connected to the 10-way valve 24 is used to continue the sampling and measurement operations at the same sampling point P4 while the remaining three diffusion scrubbers 17, 18, and 19 connected to the

10-way valves 21, 22, and 23 are used to perform the above-described sampling and measurement operations at the nine sampling points P1 to P3 and P5 to P10 other than P4. Thus, the sampling point P4 in question is continuously monitored and at the same time, the remaining nine sampling points P1 to P3 and P5 to P10 are alternately monitored by using the three diffusion scrubbers 17, 18, and 19 in the specific sequence.

Detailed Description Text - DETX (74):

The assignment of the diffusion scrubbers 17, 18, 19, and 20 to the sampling points P1 to P10 is scheduled according to the sequence shown in Table 1. An example of the schedule is shown in FIG. 10. In FIG. 10, the reference character a denotes the total duration of the pre-treatment and sampling operations, the reference character b denotes the duration of the rinsing operation, and the reference character c denotes the duration of the separation/analysis operation.

Detailed Description Text - DETX (75):

Next, the operation of the diffusion scrubbers 17, 18, 19, and 20 and the flow of the sampled air and the absorbing and eluting liquids are explained in more detail below.

Detailed Description Text - DETX (76):

Each of the diffusion scrubbers 17, 18, 19, and 20 is repeatedly subjected to one of the pre-treatment, rinsing, sampling, and separation/analysis operations according to the schedule shown in FIG. 10. For example, the duration of each operation is set as 25 minutes for the pre-treatment operation, 0.5 minute for the rinsing operation, 7.5 minutes for the sampling operation, and 8 minutes for the separation/analysis operation.

Detailed Description Text - DETX (77):

The flow path comprising the diffusion scrubber 17 and the concentration column 26 constitute a "first flow line".

Detailed Description Text - DETX (78):

In the pre-treatment operation of the first flow line, the absorbing liquid flows as follows. Specifically, the absorbing liquid is sucked by the pre-treatment pump 13 from the unillustrated container and then, is supplied to the inside of the diffusion scrubber 17 by way of the valve 1 and the liquid path 17b. The absorbing liquid in the scrubber 17 is moved to the valve 1 again, thereby being discharged to the outside through the valve 1. At this

time, the path for the eluting liquid comprising the concentration column 26 is used for the operation for the diffusion scrubber 18.

Detailed Description Text - DETX (80):

In the sampling operation of the first flow line, the absorbing liquid, which is sucked by the circulating pump 14 from the unillustrated container, is circulated along the path by way of the valve 4, the concentration column 26, the valve 4, the valve 2, the valve 1, the diffusion scrubber 17, the valve 1, the valve 2, the trap 50, the valve 3, and the pump 14. During this circulation, the absorbing liquid absorbs the trace substances (i.e., the water-soluble cations) contained in the sampled air and at the same time, the absorbed substances are concentrated by the concentration column 26 and held therein.

Detailed Description Text - DETX (82):

The paths of the valve 8 are determined according to the operations of the diffusion scrubbers 19 and 20. Specifically, the valve 8 allows the eluting liquid to pass through the column 27 for sampling or to bypass the column 27 for separation and analysis.

Detailed Description Text - DETX (83):

In the separation/analysis operation of the first flow line, the absorbing liquid, which is sucked by the circulating pump 14 from the unillustrated container, is moved along the path by way of the valve 4, the valve 2, the valve 1, the diffusion scrubber 17, the valve 1, the valve 2, the trap 50, and the valve 3, thereby being discharged to the outside from the valve 3. At this time, the absorbing liquid does not pass through the concentration column 26. On the other hand, the eluting liquid, which is sucked by the pump 25 from the unillustrated container through the degasser 45, is moved through the valve 4, the concentration column 26, the valve 4, the valve 8, the separation column 28, the suppressor 60, and the electrical conductivity meter 61, thereby being discharged to the outside. The eluting liquid does not pass through the concentration column 27.

Detailed Description Text - DETX (85):

The flow path comprising the diffusion scrubber 18 and the concentration column 26 constitute a "second flow line".

Detailed Description Text - DETX (87):

The flow path comprising the diffusion scrubber 19 and the concentration column 27 constitute a "third flow line".

Detailed Description Text - DETX (88):

In the pre-treatment operation of the third flow line, the absorbing liquid is sucked by the pre-treatment pump 16 from the unillustrated container and then, is supplied to the inside of the diffusion scrubber 19 by way of the valve 5 and the liquid path 20b. The absorbing liquid in the scrubber 19 is moved to the valve 5 again, thereby being discharged to the outside through the valve 5. At this time, the flow paths for the eluting liquid comprising the concentration column 27 are used for the operation for the diffusion scrubber 20.

Detailed Description Text - DETX (90):

In the sampling operation of the third flow line, the absorbing liquid, which is sucked by the circulating pump 15 from the unillustrated container, is circulated along the path by way of the valve 8, the concentration column 27, the valve 8, the valve 6, the valve 5, the diffusion scrubber 19, the valve 5, the valve 6, the trap 51, the valve 7, and the pump 15. During this circulation, the absorbing liquid absorbs the trace substances (i.e., the water-soluble cations) contained in the sampled air and at the same time, the absorbed substances are concentrated by the concentration column 27 and held therein.

Detailed Description Text - DETX (92):

The paths of the valve 4 are determined according to the operations of the diffusion scrubbers 17 and 18. Specifically, the valve 4 allows the eluting liquid to pass through the column 26 for sampling or to bypass the column 26 for separation and analysis.

Detailed Description Text - DETX (93):

In the separation/analysis operation of the third flow line, the absorbing liquid, which is sucked by the circulating pump 15 from the unillustrated container, is moved along the path by way of the valve 8, the valve 6, the valve 5, the diffusion scrubber 19, the valve 5, the valve 6, the trap 51, and the valve 7, thereby being discharged to the outside from the valve 7. At this time, the absorbing liquid does not pass through the concentration column 27. On the other hand, the eluting liquid; which is sucked by the pump 25 from the unillustrated container through the degasser 45, is moved through the valve 4, the concentration column 27, the valve 4, the valve 8, the separation column 28, the suppressor 60, and the electrical conductivity meter 61, thereby being discharged to the outside. The eluting liquid does not pass through the concentration column 26.

Detailed Description Text - DETX (95):

The flow path comprising the diffusion scrubber 18 and the concentration column 26 constitute a "fourth flow line".

Detailed Description Text - DETX (100):

In the sampling operation, the valve 3 have the ways shown by broken lines in FIG. 8. Therefore, the port c' of the trap 50 in FIG. 11 is closed, resulting in the way connecting the port a' with the port b'. Thus, the absorbing liquid supplied from the diffusion scrubber 17 or 18 through the valve 2 flows through the trap 50 at the ports a' and b'. Since the trap 50 is fixed in such a way that the port c' is located upward, only the foams contained in the absorbing liquid flowing through the trap 50 are trapped in its reservoir 50a and are not moved to the valve 3. This means that the foams are effectively removed from the absorbing liquid by the trap 50.

Detailed Description Text - DETX (101):

The separation/analysis operation begins after the sampling operation is completed. In the separation/analysis operation, the valve 3 have the ways shown by solid lines in FIG. 8. Therefore, the port b' of the trap 50 in FIG. 11 is closed, resulting in the way connecting the port a' with the port c' Thus, not only the absorbing liquid supplied from the diffusion scrubber 17 or 18 but also the trapped foams in the reservoir 50a flow out of the trap 50 through the port c' to be discharged.

Detailed Description Text - DETX (105):

In the prior-art trap 750 of FIG. 5, in the sampling operation, the port c" of the trap 750 is closed, resulting in the way connecting the port a" with the port b". Thus, the absorbing liquid supplied from the diffusion scrubber 17 or 18 through the valve 2 flows into the trap 750 through the port a" and flows out of the trap 750 through the port c". Only the foams contained in the absorbing liquid flowing into the trap 750 are trapped in its reservoir 751 and are not moved to the valve 3. The reference numeral 752 is the absorbing liquid stored in the trap 750. The inner space over the store liquid 752 serves as the reservoir 751.

Detailed Description Text - DETX (125):

The sampler 100, which is connected with a sampling point P in a clean room for semiconductor device fabrication, produces a sample of the air in the clean room at the point P. The sampled air contains trace substances such as ammonia and monoethanolamine existing in the air. The trace substances in the sampled air are then absorbed into an absorbing liquid, thereby producing a sample AL of the trace

substances.

Detailed Description Text - DETX (133):

As shown in FIG. 13, the sampler 100 includes a sampling tube T and a diffusion scrubber 109. The concentrator 200 includes a concentration column 114. The analyzer 300 includes a separation column 115, a suppressor 116, and an electrical conductivity meter 117. The concentration column 114, the separation column 115, the suppressor 116, and the electrical conductivity meter 117 are part of an ion chromatograph 170. The cleaner 500 includes a valve 105 and a purging gas tank 119.

Detailed Description Text - DETX (136):

As shown in FIG. 14, the sampler 100 has the sampling tube T, the diffusion scrubber 109, a trap 110, a MFC 118, and a pump 106 for sucking the air.

Detailed Description Text - DETX (137):

The diffusion scrubber 109 has the same configuration as that of the diffusion scrubbers 17, 18, 19, and 20 used in the first embodiment of FIG. 8.

Detailed Description Text - DETX (138):

One end of the sampling tube T is located at the sampling point P in the clean room and the other end is connected to the scrubber 109. The air existing in the clean room is sampled at the point P and sent to the scrubber 109 through the tube T due to the sucking operation of the pump 106.

Detailed Description Text - DETX (139):

The scrubber 109 has an air path 109a through which the sampled air flows and a liquid path 109b through which an absorbing liquid flows. One end of the air path 109a is connected to the tube T and the other end is connected to a port of the valve 105. The sampled air is sent to the air path 109a through the tube T and the scrubber 109.

Detailed Description Text - DETX (140):

The ways in the valve 105 are controlled to connect the air path 109a with the trap 110 in any time except for the cleaning operation, thereby allowing the sampled air to flow through the scrubber 109. In the cleaning operation, the valve 105 is operated to connect the air path 109a with the MFC 120 of the cleaner 500, thereby allowing the

purging gas stored in the tank 119 to enter the air path 109a and the inside of the scrubber 109. Thus, the air path 109a and the inside of the scrubber 109 are cleaned.

Detailed Description Text - DETX (141):

The trap 110 serves to trap the leakage of the absorbing liquid from the scrubber 109 and the moisture from waterdrops induced by pressure difference. The trap 110 is located at a level lower than that of the scrubber 109.

Detailed Description Text - DETX (143):

The pump 106 is used to suck the air at the sampling point P in the clean room to the diffusion scrubber 109 through the tube T. The pump 106 is located at the outlet side of the MFC 118.

Detailed Description Text - DETX (144):

The concentrator 200 includes a degasser 112, a valve 102, the diffusion scrubber 109, a valve 101, a valve 104, a pump 107 for circulating the absorbing liquid, a trap 111, and the concentration column 114. The trace substances such as ammonia and monoethanolamine absorbed into the absorbing liquid are concentrated and held in the concentrator 114. The trace substances such as ammonia and monoethanolamine are absorbed into the absorbing liquid in the diffusion scrubber 109.

Detailed Description Text - DETX (145):

The degasser 112 removes the gas existing in the absorbing liquid. As the absorbing liquid, ultrapure water is used here. The valve 102 switches the ways of the absorbing liquid sucked through the degasser 112. The valve 101 switches the ways of the absorbing liquid sucked by the pump 107, thereby allowing the absorbing liquid to be sucked into the diffusion scrubber 109 or to be circulated. The valve 104 switches the ways of the absorbing liquid sucked by the pump 107, thereby allowing the absorbing liquid to be discharged to the outside in the rinsing operation or to be circulated.

Detailed Description Text - DETX (146):

The pump 107 for circulating the absorbing liquid sucks the absorbing liquid containing the desired substances through the degasser 112 and sends it to the valve 103. In the pre-treatment operation, the valves 101, 102, 103, and 104 are all closed and therefore, the absorbing liquid sucked from the unillustrated container flows through the diffusion scrubber 109 and is discharged to the outside by the pump 107.

Detailed Description Text - DETX (147):

The trap 111 serves to trap the leakage of the absorbing liquid from the diffusion scrubber 109 and the moisture from waterdrops induced by pressure difference. The trap 111 is located at a level lower than that of the scrubber 109.

Detailed Description Text - DETX (150):

The valve 103 serves also to discharge the absorbing liquid in the rinsing operation to remove the residue in the concentration column 114. In the sampling operation, the valve 103 is opened to connect the diffusion scrubber 109 with the concentration column 114, allowing the trace substances in the absorbing liquid to be accumulated in the column 114.

Detailed Description Text - DETX (153):

The cleaner 500 comprises the purging gas tank 119, a MFC 120, and the valve 105, which cleans the inside of the sampling tube T, the diffusion scrubber 109, and the air path 109a. The tank 119 stores the purging gas. As the purging gas, any inert gas such as pure nitrogen gas may be used. The MFC 120 controls the flow rate of the purging gas.

Detailed Description Text - DETX (154):

The valve 105 switches the way to the end of the diffusion scrubber 109. In the cleaning operation, the valve 105 is operated to connect the diffusion scrubber 109 with the MFC 120, allowing the purging gas to enter the scrubber 109. In the operations other than the cleaning operation, the valve 105 is operated to connect the diffusion scrubber 109 with the MFC 118, allowing the absorbing gas to be discharged to the outside.

Detailed Description Text - DETX (157):

In the step S1, the "cleaning operation" is carried out, in which the purging gas is supplied to the diffusion scrubber 109, the air path 109a, and the sampling tube T. The purging gas thus supplied is discharged from the end of the tube T at the sampling point T. Thus, the inside of the diffusion scrubber 109, the air path 109a, and the sampling tube T is cleaned.

Detailed Description Text - DETX (158):

In the step S2, the "pre-treatment operation" is carried out, in which the absorbing liquid (i.e., ultrapure water) is supplied to the diffusion scrubber 109 to wash its inside and the relating flow

paths. Thus, the remaining trace substances are removed or decreased. The absorbing liquid thus supplied is then discharged to the outside.

Detailed Description Text - DETX (160):

In the step S4, the "sampling operation" is carried out, in which the sampled air and the absorbing liquid (i.e., ultrapure water) are supplied to the diffusion scrubber 119. The trace substances contained in the sampled air are absorbed into the absorbing liquid in the scrubber 109. The absorbing liquid containing the trace substances is then supplied to the concentration column 114, thereby concentrating the substances and held in the column 114. The absorbing liquid from which the substances have been extracted is then returned to the scrubber 109.

Detailed Description Text - DETX (162):

During the step S5 is carried out, the "cleaning operation" is performed in the step S6 and then, the "pre-treatment operation" is performed in the step S7 for a next measuring step. Thus, the residue of the trace substances in the sampling tube T and the diffusion scrubber 109 generated in a prior measuring step is removed.

Detailed Description Text - DETX (168):

In the cleaning operation, the air-sucking pump 106 is stopped and the valve 105 is operated to connect the diffusion scrubber 109 with the purge gas tank 119. Then, the purge gas in the tank 119 is supplied to the inside of the scrubber 109 through the air path 109a at the specific flow rate and then, is discharged to the outside through the tube T.

Detailed Description Text - DETX (169):

In the pre-treatment, rinsing, and sampling operations, the valve 105 is closed to connect the diffusion scrubber 109 with the trap 110 while the air-sucking pump 106 is driven to perform its sucking operation. Thus, the air in the clean room is collected or introduced into the scrubber 109.

Detailed Description Text - DETX (171):

In the cleaning and pre-treatment operations, the absorbing liquid is sucked from the container by the pump 107 and is discharged to the outside through the flow path 109b, the diffusion scrubber 109, and the trap 111.

Detailed Description Text - DETX (173):

In the sampling operation, the absorbing liquid is sucked from the container by the pump 107 and is circulated through the circulating path comprising the valve 103, the concentration column 114, the valve 103, the valve 104, the diffusion scrubber 109, the valve 102, the valve 104, the trap 111, the valve 101, and the pump 107. Thus, the trace substances contained in the sampled air is absorbed into the absorbing liquid in the diffusion scrubber 109 and then, the absorbed substances into the absorbing liquid are concentrated and held in the concentration column 114.

Detailed Description Text - DETX (174):

In the separation/analysis operation, the absorbing liquid is sucked from the container by the pump 107 and is discharged to the outside through the path comprising the valve 101, the valve 101, the valve 103, the valve 104, the diffusion scrubber 109, the valve 102, the valve 104, the trap 111, and the valve 101. The absorbing liquid does not pass through the concentration column 114 in this operation.

Claims Text - CLTX (2):

2. The apparatus as claimed in claim 1, wherein said desired substance is gaseous and each of said concentrators has a diffusion scrubber and a concentration column.

Claims Text - CLTX (9):

9. The apparatus as claimed in claim 1, wherein each of said diffusion scrubbers has a cleaner for cleaning the same by supplying a purging gas.

Claims Text - CLTX (11):

11. An apparatus for automatically analyzing a trace substance, comprising: (a) samplers for making samples at different sampling points, each of said samples containing a desired substance; (b) concentrators for concentrating the substance contained in said samples to thereby produce concentrated samples; (c) a quantitative analyzer for analyzing quantitatively said substance contained in said concentrated samples; and (d) a controller for controlling said samplers, said concentrators and said analyzer to cause automatically operations of said samplers, said concentrators, and said analyzer repeatedly at specific intervals of time; wherein each of said concentrators receives alternatively one of said samples from one of at least two of said samplers; wherein said analyzer receives alternatively said concentrated samples from said concentrators; and wherein said desired substance is gaseous and each of said concentrators has four diffusion scrubbers and two concentration columns.

Current US Cross Reference Classification - CCXR (3):

422/93